MOIRE

Membrane Optic Image Real-Time Exploitation

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Mirror Technology SBIR/STTR Workshop
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What makes DARPA unique…

Formed in 1958 to PREVENT and CREATE strategic surprise

Capabilities, mission focused

Finite duration projects

Diverse performers

Multi-disciplinary approach…from
basic research to system engineering

As the DoD's innovation engine, we
are committed to the boldest, creative leaps…

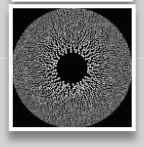
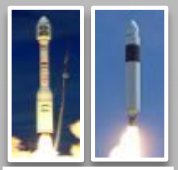
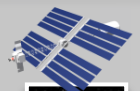
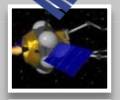
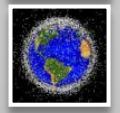
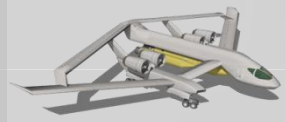
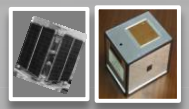
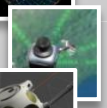
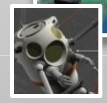
DARPA TTO

TTO transforms the future of warfighting by pursuing high-risk, high payoff tactical technology and development of rapid, mobile and responsive combat capability for advanced weapons, platforms and space systems.

- **Creating highly capable systems that enable "order of magnitude" improvement in military capabilities in a rapidly changing technological landscape**
- **Investing in research and technologies that enable strategic advantage over technological surprise in TTO focus areas**
- **Developing technologies and systems that facilitate "game changing" tactics, techniques and procedures that address the entire spectrum of armed conflict Understanding and addressing critical deficiencies in crucial mission areas**
- **Conceptualizing, demonstrating and transitioning advanced technologies and concepts for effective, survivable and cost effective military systems**

A typical DARPA TTO effort is a 3-5 year program to develop a prototype(s) showing proven technical capability

DARPA Space

DARPA Space Focus	DARPA Achievements	Current DARPA Space Programs	New DARPA Space Initiatives	Main DARPA efforts which support Rendezvous, Refuel, Refurbish, Repair, Reposition (R5) Capability Goals
Awareness	 Corona 1960  Transit 1963 GPS 1985	 MAGI  SST  SCORE	 SSA Data Fusion  MOIRE	Ground Based Space Situational Awareness • SST completion and transition • Continue to investigate low cost ground based sensors for detection and characterization Space Situational Awareness Data Fusion • Joint DARPA and Air Force effort
Agility	 Taurus 1994 Space-X 2007  Pegasus 1988	 FAST  FREND  Catchers Mitt (Study)	 Horizontal Launch (Study)	Horizontal Launch • 15,000 lbs to LEO • Conventional turbojet runway takeoff • Expendable rocket 2nd and 3rd stages
Adaptability	 DARPASAT 1987 PICOSAT 2000  Orbital Express 2007	 System F6  InSPIRE	 Nano Satellites  Persistent Comm.  Manned GEO Servicing (Study)	Manned GEO Services • Rendezvous, Refuel, Refurbish, Repair, Reposition **(R5)** • Potential joint effort with NASA

MOIRE

Program Objectives

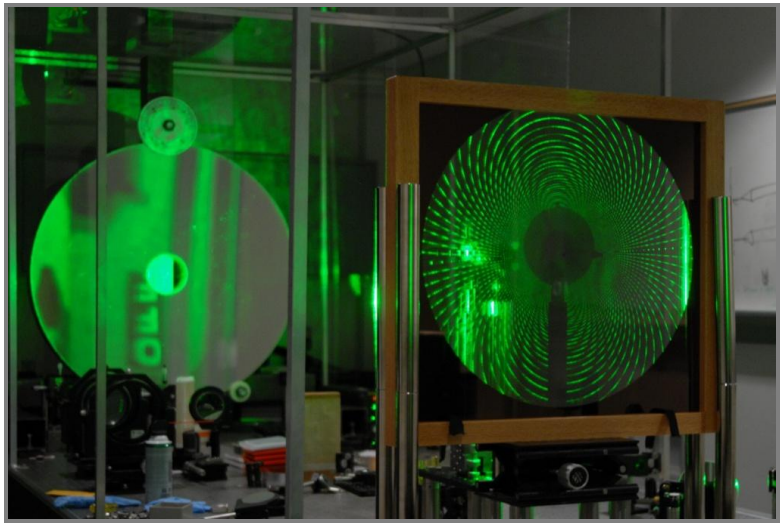
- Persistent, tactical, real-time video from geosynchronous orbit
  - 24/7 coverage of denied territory
  - Provide real-time troop movements, targeting & BDA
  - Provide vehicle tracking, missile launch detection

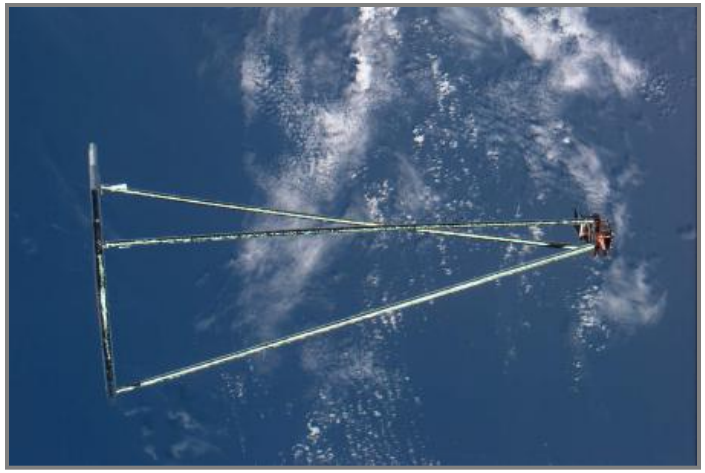
Performance Metrics

- Membrane optics system with Fresnel pattern to focus an image for 15x resolution improvement over same mass to orbit for a reflective telescope
- 500x reduction in primary optic weight for same resolution
- 10x savings in production costs compared to glass optics for same resolution

Military Utility

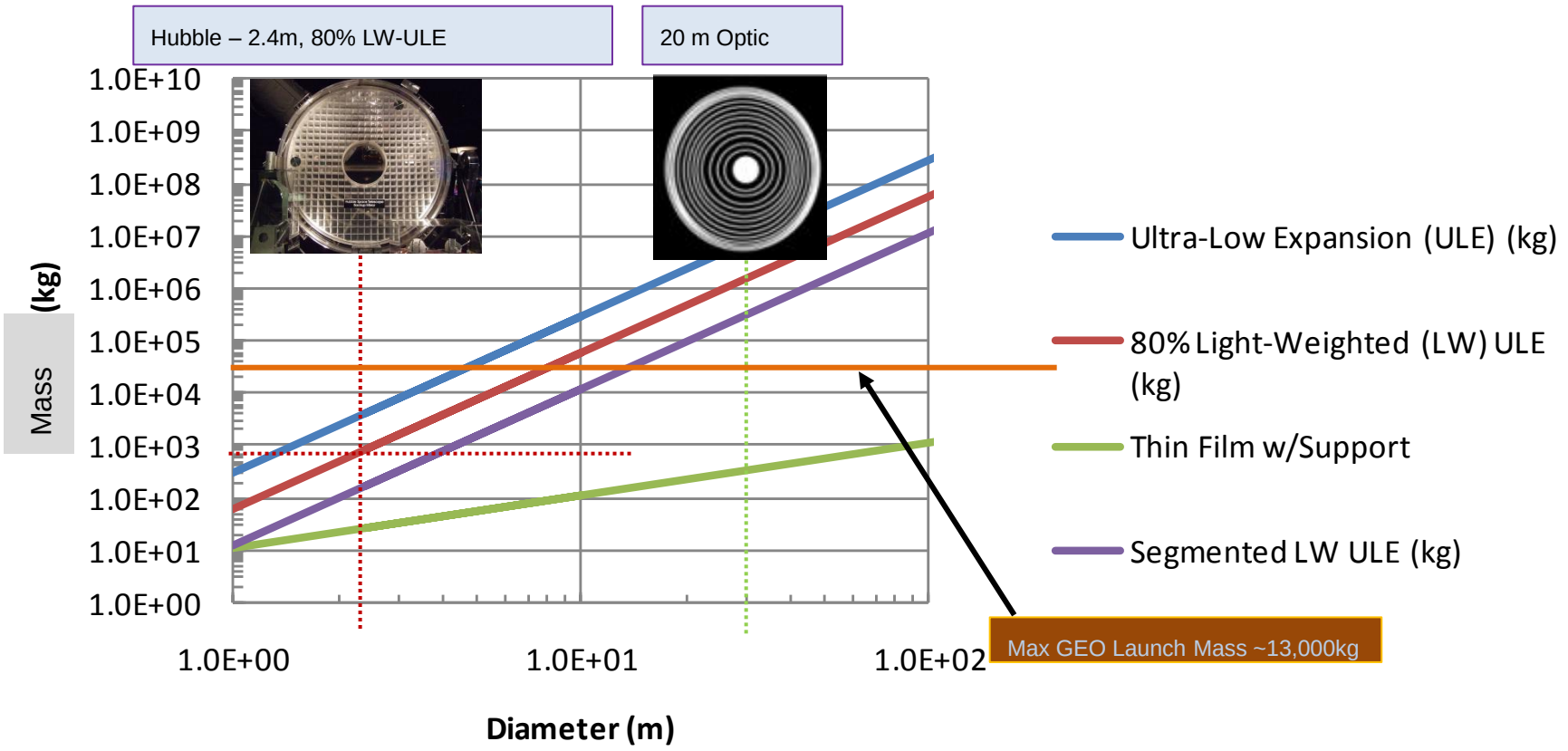
- **Real-time 1 frame/sec video to warfighters**
- One satellite can image 1/3 of earth's surface, without changing orbit, at 1 meter ground sample distance resolution





MOIRE will provide persistent, tactical video coverage to the warfighter

Diffractive Optics Enable Cost Effective Tactical GEO Imager



JWST (next gen. SOA)

- 6m, segmented, glass deployable reflective concept
- $250M NASA Phase A study
- Typical $3-4B solution
- S/C Mass – 10,000 kg
- 38 nm design tolerance
- 20+ year development time

MOIRE

- 20 m membrane
- Proposed $20M Phase I
- <$500M operational system
- S/C Mass ~3,000 kg
- 10 um design tolerance
- 5 year development time

MOIRE Objective System

Design Reference Mission Performance Goals

- Persistence – 24/7
- Missile launch detection & vehicle tracking
- VNIIRS – 3.5+
- Ground Sample Distance -- ~ 1m
- Visible/IR Video @ > 1 Hz
- Field of View > 100 sq km
- Field of Regard – 15,000 km by 15,000 km (without slewing)
- < $500M/copy (after R&D)

Performers

- Ball Aerospace and Technologies Company, Broomfield, CO
  - ATK Space Systems, Inc., Goleta, CA
  - Lawrence Livermore National Laboratory, Livermore, CA
  - NeXolve Corporation, Huntsville, AL
- Northrop Grumman Aerospace Systems, El Segundo, CA
  - NeXolve Corporation, Huntsville, AL
  - Astro Aerospace, Carpinteria , CA

Phase 1 efforts will complete September 2011

MOIRE Schedule

Phase 1 - Optical Component Performance

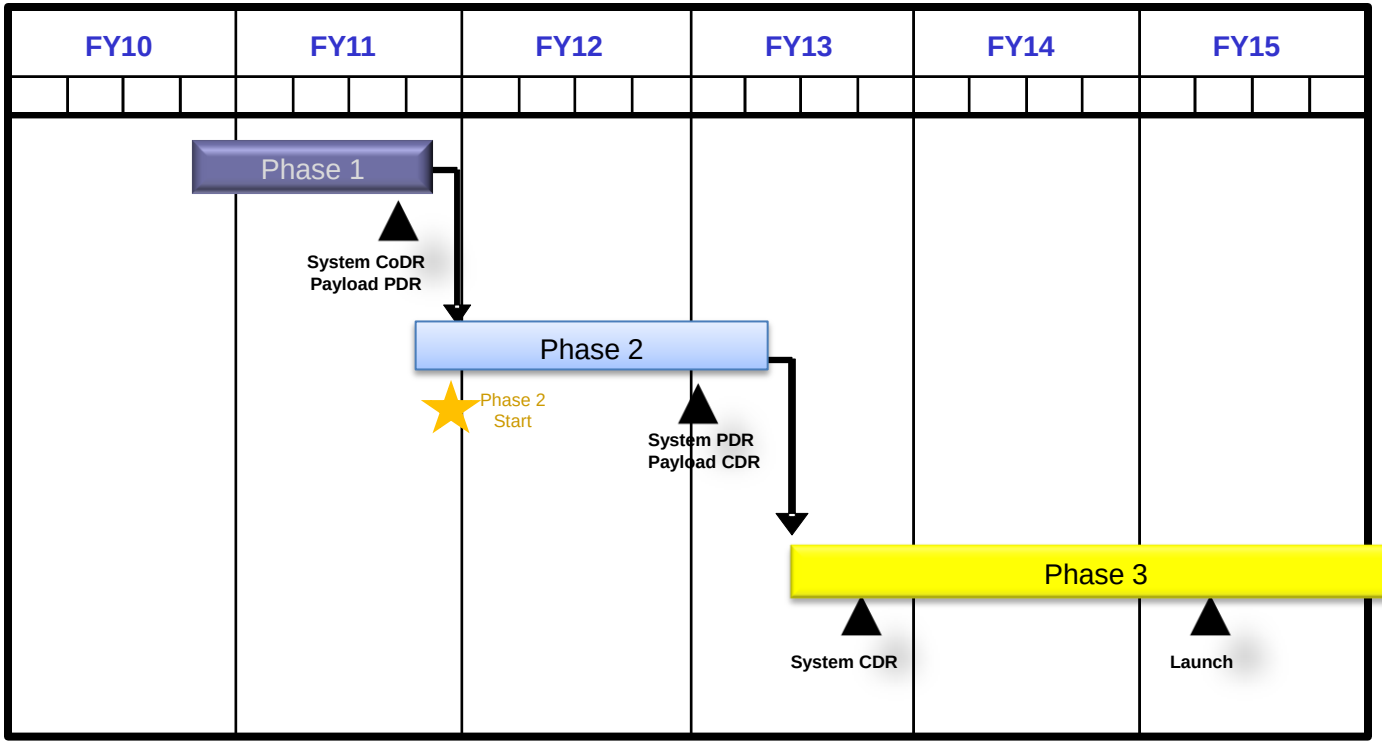
- Validation of optical prescription, design and structure
- Major optical risks retired

Phase 2 - Optical System Design

- Validation of subsystem elements
- Manufacturing validated
- Structure risks retired
- ETE NIIRS Model

Phase 3

- 10 m space telescope demo
- Space M&S validated



Phase 1 - base

- Two awards
- 12 months
- Diffractive membrane lens at 1m tested for optical prescription

Phase 2 – priced option

- One selected to continue
- 18 months
- Subsystem fabrication, test, and control
- Manufacturing and alignment demo
- Imaging telescope design traceable to GEO concept and NIIRS objective
- Ends in PDR

Phase 3 –option

- Notionally 36 months
- 10 m prototype demo

PI & PII Program Metrics

Metric	Phase 1	Phase 2
Membrane	Fabricate And Test **1 m** Primary Optic Measure Spatial PSF & Efficiency Measure Spectral Minimum Of **50 nm** Band Pass Maturity Breadboard Telescope Primary, lab detector Space Environmental Testing **Coupon Level**	Fabricate And Test **5 m** Primary Optic Measure Spatial PSF & Efficiency Measure Spectral Minimum Of **70 nm** Band Pass Maturity Brassboard Telescope Primary, "Spectral Combiner", Flight Like Detector Space Environmental Testing **Membrane Level**
Structure	Modeling And Simulation Packaging And Deployments Sims At CoDR Level	Scale (Or Fractional) Demonstration Fabrication & Testing For Deployment Concept
Image Quality/Quantity	Present At Payload PDR Using: 1 m Measured Data (PSF/Efficiency/Wavefront) Structural Dynamics Sims Simulated 20 m System VNIIRS At 3.5+ Ability To Image Vehicles Moving At 60 Mph	Present At System CoDR Using: 5 m Measured Data (PSF/Efficiency/Wavefront) Structural Dynamics Tests/Sims Simulated 20 m System VNIIRS At 3.5+ Ability To Image Vehicles Moving At 60 Mph
Cost Modeling DRM – Non Recurring Cost Analysis For Operational System, $500m Constraint	Incorporating 1 m Test Knowledge, Modeling & Simulation, System CoDR	Incorporating 5 m Knowledge, Structural Test/Modeling & Simulation, System PDR

Phase 3 – 10 m Flight Demo, 1000 kg, EELV Medium to GEO, 5 Meter Fairing

Metrics Ensure Traceability to An Operational System Meeting Warfighter Utility Needs and DoD Fiscal Constraint Realities

Summary

MOIRE seeks to provide tactical video coverage and missile launch and detection

Membrane, diffractive optics enable relatively low cost solution for GEO based imager

Future system enhancements can provide greater spectral content and improved resolution

MOIRE Phase 1 ground demonstrations will focus on payload risk reduction, large scale fabrication, image quality metrics, structural deployment, and image processing

MOIRE Phase 1 will culminate with a space system CoDR and payload PDR

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Backup

Link Budget – Efficiency / Narrowband Challenge

Adequate SNR At Existing 0.35% Efficiency, Integration of 0.1 sec

SNR	14 dB
Aperture	10 m
Detector Pitch	8 micron
F#	15
GSD	2 m
Efficiency	0.35% measured
Integration	0.5 sec
Wavelength	532 nm
Ground Reflectance	2%

- Simulated image assuming parameters above.
- Image is narrowband converted to grayscale.
- Image is estimated to be better than NIIRS 3.5
- Image contains realistic shot and read noise